Devonian, Carboniferous and Permian systems. The vegetable fossils of the Silurian system consist of low forms of sea weeds, and the animal fossils as yet found and undisputed are Foraminifera, Sponges, Hydrozoa, Corals, Crinoids, Cystidians, Star-fishes, Sea-worms, Trilobites and molluscan shells of several kinds.

Next came the Devonian with ferns, club-mosses, horse-tail reeds, and traces of pine ; land snails, insects, a low type of fish similar to the sturgeon, together with trilobites, corals and molluscs more highly developed than those of the preceding system.

The next great division of the Palæozoic, the Carboniferous, is so named from the extensive coal beds then formed. There were also thick limestone deposits made up largely of corals, crinoids, polyzoa and other calcareous or lime building organisms. Coal is composed of altered and compressed beds of vegetation. Each bed of coal is generally underlain by one of fire-clay containing roots and other evidences of having once been a surface soil, probably in a marshy swamp. The accumulated vegetation submerged during subsidence, was covered with other material. The period of time during which the changes were going on was of incomprehensible duration, but none of the higher orders of plants and animals had appeared. The flowerless plants reigned almost as the sole representatives of the vegetable kingdom ; but instead of being small like their descendants of the present time, were of gigantic size. Plants resembling club-mosses were sometimes 50 feet in height. There were dragon-flies, crickets, ants, amphibians, king-crabs, and large sharks ; the trilobites died out and did not make their appearance in the succeeding period.

The Labyrinthodonta of the Carboniferous period

were amphibious, forming a connecting link between the primitive Sauroid fishes and the saurian reptiles which succeeded them.

Already a number of organic forms had become less fitted for the conditions than were their rivals and enemies—and had therefore become extinct. The fittest survived in the struggle for food and life.

In the Permian period there was a gradual transition; among animals toward the reptilian type, and the conifers among plants became more marked, and palms appeared. The first reptiles were derived from the amphibians and through them the lowest mammals originated.

The Mesozoic era was essentially the age of palms and reptiles. It is divided into three subdivisions: Triassic Jurassic, and Cretaceous. In the Triassic period there were cypress-like conifers, palms and tree-ferns, early types of lizards, reptiles with beak-like jaws, animals intermediate in structure between reptiles and birds, while in size they resembled elephants and crocodiles. There appeared also the first and lowest of mammals resembling the marsupial animals of Australia. Beds of rock-salt were deposited in the briny enclosed seas. From the saturated saline waters were deposited in succession: (1) The least soluble salt, sulphate of lime; (2) Common salt or chloride of sodium; and (3) Chloride of potassium and magnesium. Rock-salt is not confined to the Triassic periods, but has formed in every geological period including the present, for it is forming now.

During the Jurassic period, a few animal forms became extinct, while many others continued to change along the line of development toward modern types. Among the crustacea and molluscæ there was a decided

advance, but the most remarkable variety of forms was among the reptiles.

Huge reptiles swam in the water, walked on the land, or flew in the air. Some were small, many were larger than elephants, while others rivaled whales in size. There were huge vegetable feeders walking on the ground, one species of which, the Atlantosaurus, is believed to have been 100 feet in length, and more than 30 feet in height. No wonder poor bewildered Noah left them out of the ark ; or perhaps they were overlooked when he was planting trees in the ark—so the sloths could have food "after their kind,"—or identifying pairs of fresh water animalculæ with his microscope. The Jurassic contains the earliest known birds. They had teeth in their jaws—connecting them with the reptiles. Some had long lizard-like tails with a couple of feathers in each vertebra.

Still the mammals seem to have been only represented by a low type of marsupials. The Bellemnite, allied to the squid and cuttle-fish had an inkbag with which, like the squid, it sheltered itself from its enemies by ejecting an inky fluid. These inkbags have been found with the fossil ink (sepia) well enough preserved to be used for pigment.

The distinguishing feature of the Cretaceous period was, as its name implies,—White Chalk. There are extensive white chalk formations in England and northern France. The Cretaceous strata are very extensive in Europe, Asia, Africa and North America. White chalk is remarkably pure carbonate of lime, and the best is almost entirely composed of the shells of Globigerina, and other microscopic animals. The same kinds of organisms are found living, on the bottom of the North Atlantic Ocean. The microscopic appear-

ance and chemical properties of the mud or ooze on the ocean bottom are substantially the same as the chalk, and when it is dried it makes a grayish white marking chalk. Thus we have a very ancient and general geological formation extended to the times in which we live,—for white chalk is now forming. The chalk deposits of England, Texas, etc., composed principally of Globigerina, as they are,—were formed when the areas they cover were part of a deep sea bottom. Besides, the present Atlantic chalk formation is continuous with the chalk of England, and Central Europe. In one sense we live in the Cretaceons period. If the records were complete there can be no doubt that all geological periods would be intimately connected. Unlike other animals and plants the chalk organisms changed very little in millions of years ; their environments remaining substantially the same, and few competitors were encountered for their peculiar deep-sea existence. These facts are regarded as strengthening the evolution theory.

During the Cretaceous period reptilian life seems to have declined, and we find the earliest known true bony fishes, such as the salmon, pike, perch, herring and cod. An important advance was also made in plant life. There developed in that long period,—the California Sequois, (or Red Wood,) juniper, and species of alder, maple, oak, walnut, beech, poplar, dogwood, sassafras, and others, similar to, but not identical with their descendants of the present day.

There were toothed birds with vertebræ like those of fishes and extinct reptiles. They had thin slender jaws instead of beaks.

The Cenozoic or Tertiary era, or age of mammals, is subdivided into the Eocene, Miocene, and Pliocene periods. The geographical changes that took place, brought the

continents and oceans, to more closely resemble in position and contour, those now existing. The temperature as indicated by the character of the fossils, was higher than at present. The ocean during the Cretaceous period, had extended up the Mississippi valley to near the junction of the Ohio river, and covered the plains westward to the mountains. The continent was gradually elevated, until in the Tertiary period, while Florida and the lower Mississippi valley still remained under the sea, the central plains west of the Missouri, became the beds of extensive lakes. They continued for a great period of time, during which deep fossil-bearing deposits were formed in their basins. Large lava-fields, the outpourings of volcanoes and great fissures, were formed, extending over large portions of California, Nevada, Oregon, Washington, Idaho, and British Columbia.

During the Eocene and Miocene, the Sequois became almost identical with the big red-wood trees of California, and magnolias, elm, willow, chestnut, plum, etc., resembled those of the present time. Extensive deposits were formed of the almost clear silicious shells of microscopic uni-cellular plants,—the Diatoms, in some places like the Richmond, Va., deposit—thirty feet thick. Those familiar with the habits of living diatoms, can imagine the great length of time required for such deposits.

Reptiles had to retire before the more intelligent mammals ; the brain became larger in proportion to the size of the animal. It was developed by use. The higher and more migratory animals, sharpened by the variety of their surroundings, developed faster than the lower invertebrates and molluscs. The mammals became numerous, and stood at the head during the Tertiary periods. Bees, ants, and butterflies came to the front rank of insect life. There were species of apes, monkeys,

deer, and the progenitors of the horse. The reptilian birds became extinct, and their descendants, water birds, and land birds, became numerous.

In the Pliocene period, the upward march continued as always before,—an unbroken steady movement. This general evolution can be best illustrated, perhaps, by taking a single example like the horse. Most animals, the original type,—have five foes. The horse has but one toe, with its nail strengthened and developed into a hoof. Now, the Eohippus of the Eocene period had four toes on the fore-foot, and three on the hind-foot, and the rest were rudimentary. The animal was as small as a fox. Later in .the same period the Orohippus, its probable descendant had lost the rudimentary dew-claw. In the Mesohippus of the Miocene the fourth toe of the fore-foot had disappeared, and was represented by a splint. Then, still in the Miocene, we have the Miohippus with the said splint nearly gone; the side toes diminished, and the animal as large as a sheep. Its Lower Pliocene descendant, the Protohippus, was still nearer like a horse, had lost the useless splint entirely, the side toes did not touch the solid ground, and it was the size of an ass. In the later Pliocene the descendant of this animal, the Pliohippus, was nearly a horse, had only one hoof on each foot, the two side toes being represented by splints. In the next period came the true horse with splints shorter, and shape and size perfected along with the feet. This is the story of the "creation" of the horse (and the other animals and plants) according to geologists and according to nature and the facts; and it was done more than 6,000 or 600,000 years ago, and took more than 6 or 600,000 days, and was done by natural selection. The work by the same methods is still going on,—and the day of rest is not in sight.

The Quaternary period is the last main division of the geological record. Early in the period, two important events must be noted: the Glacial, or Ice Age, and the development of a variety of man, competent to invent weapons, by using which he gained supremacy over the other species of animals. The struggle to which we refer began with animals that became extinct before any written records were preserved. Up to very recent times the descendants of those primitive men have warred with similar, but improved, flint implements against each other, and against living species of the lower animals. Judging by the time taken for the known development of man, his comparatively high development so early in the Quaternary period, and his so general distribution in both hemispheres, at that early time, would indicate that he must have well bridged by evolution, any gap between himself and the man-like apes as early as the Pliocene period.

In the Tertiary period tropical animals had roamed the temperate zones, and the climate of Greenland as proved by the fossils, was then mild. The Quaternary was ushered in by the gradual elevation of the northern portions of Europe, Asia and North America, with a corresponding southerly subsidence. This change went on until the rising areas had attained an elevation of some 2,000 or 3,000 feet above the present level. Greenland is now covered with a sheet of ice 3,000 to 6,000 feet thick. Such a sheet was then gradually forming, increasing year by year in thickness and extent, until in summer and winter, for many thousands of years, the Earth was covered with such an ice-blanket down to about forty degrees north latitude. This vast field of ice was then, as is now the case with the ice-sheet of Greenland, moving at a slow and steady rate in a southerly direction. Such

glacial movements are now seen also in the Alps, and other mountains, moving slowly down and carrying with them frozen-in fragments of rock to be ground and rounded, and left stranded or in heaps as the surface of the ice melts, and the glacier retreats. Such evidences as are known to be left by the mountain glaciers were left behind by the great ice-sheet of the Glacial period. It retired as slowly and gradually as it came on. Sometimes it would remain about the same for years; at one period it again advanced, before finally returning to its present limits.

Along the southern limit of the ice-sheet, and along the margin of its second great advance, are traced lines of terminal moraines; hills composed of boulders, earth, gravel, stones of all sizes, and clay,—commonly called drift. This is composed of granite and other rock material foreign to the places where found, but belonging to well-known strata farther north. Many of the rocks were brought in the ice hundreds of miles, and sometimes across valleys over one thousand feet deep. This glacial drift, with its conspicuous boulders is scattered over hills and valleys, everywhere north of the forty degree limit, and is of varying depth—from 30 to 300 feet. The surface of the rocks, immediately underlying this accumulation of glacial detritis, are marked and striated north and south by angular stones, frozen in the bottom of the mass of moving ice. No such marks and no such boulders are found in low latitudes, unless caused by mountain glaciers, or where favored by local conditions.

The Glacial period was probably caused by the changes in the elevation of the land, the discharge of the Gulf Stream across the then sunken isthmus into the Pacific, the withdrawal of all considerable ocean currents from flowing into northern regions, the Earth being in that

part of its orbit farthest from the Sun in winter, and in addition to this, the orbit of the Earth had reached its maximum period of eccentricity. Mr. Croll, from the astronomical data above indicated, thinks the Glacial period began 240,000 years ago, and ended about 80,000 years ago. These figures are to be taken with considerable allowance for there are good reasons for thinking that the geographical causes were more potent than the astronomical.

When the cold period had reached its height, the elevated northern regions began to subside, and the downward movement continued, until vast tracts that are now dry land were under water and the ice gradually retreated. The descendants of arctic animals that had been driven south by the cold, returned to their northern homes, but traces of arctic vegetation still remain far south of their original home. During the period that has since elapsed the land has gradually changed to its present level ; but changes of level are yet constantly going on.. For instance, Norway and Sweden are now rising at a steady rate that has been accurately measured.

There was a gradual passage from one geological period into another. It is impossible to tell where one ended, and another began ; indeed, it can be said that in fact all geological changes are embraced in one great period of incomprehensible duration. The changes and the evolution, produced by the same causes, are going on to-day, the same as ever.

The plants and invertebrate animals of the present time, differ but little from those of the Quaternary period. They changed their habitat with the changing climate, moving northward since the Glacial period. On the other hand the mammalian fauna is almost wholly changed. The remains of these extinct species are often

found in a good state of preservation. Specimens of the Mammoth were found frozen in the ice in Siberia,—preserved so perfectly, that dogs ate of their flesh. These animals were twice as large as the common elephant, and were covered with wool or hair. Many skeletons of the great Mastodon have been found in the United States,—in marshes where they had mired and died. One found in the edge of a swamp near Wayland, N. Y., had among the ribs a large quantity of chewed material, evidently the contents of the stomach. On being examined with a microscope, this material was found to consist principally of the foliage and twigs of coniferous trees. These animals were much larger than elephants, having been about thirteen feet high, and twenty-five feet long. There were at that time in America two species of elephants, horses, gigantic bisons, and beavers, bears, lions, etc.

If the frequency with which remains are found is a criterion from which to judge, the large mammalia must have been very numerous. It was the culminating period of mammalian quadrupeds.

For untold centuries there had been developing from among the anthropomorphous apes, an animal destined to play a remarkable and most important part in the struggle for existence. Forced by the necessities of his environments, and the superior strength of his enemies, to use all his wits to secure to himself and progeny safety and food,—constant use strengthened, and exceptionally developed his brain. Compelled to live in the tree-tops, his fore-feet became, by small gains, continued through a great length of time, hands. Necessity is the mother of invention. The great mammals of the Pliocene, and of the Quaternary periods were formidable competitors. Their supremacy seemed assured; but at

this crisis the ape-man made a great stride in advance, by which his position at the head was secured. He invented, and with his dextrous hands was able to construct, artificial weapons. The great quadrupeds, with their clumsy toes and lazy brains, were outmatched by the quick-witted, nimble-fingered little fellow.

There is conclusive evidence that man was contemporaneous with the extinct animals of the Quaternary period. Beneath river-loam, twenty to thirty feet thick, in terraces of the river Somme, at different levels, there have been found in the undisturbed gravel—unquestionable flint implements, associated with the bones of extinct species of the hippopotamus, elephant, rhinoceros, hyena, etc. At Biddenham, England, true flint implements were found in river-gravel with the bones of extinct species of the reindeer, cave-bear, mammoth, bison, rhinoceros, hippopotamus, etc. A true flint implement has been found in a rounded pebble.

In many caves in different countries human bones and tools have been found together with the bones of animals now extinct. In a cave at Neanderthal, a human skeleton was found, with large limb-bones, and very thick and low skull. At Engis, on the Neuse, with bones of extinct and living species, and beneath a crust of stalagmite, a rather well-shaped human skull was taken out. A similar specimen was found at Mentone, near Nice. In a cave in Belgium human bones were found with those of extinct Quaternary animals. These bones indicate that the men were of a low type;—bent knees and a semi-erect posture.

Beneath the stalagmite floor of Kent's Cavern, England, was found a bone harpoon-head of fine construction. A piece of reindeer-horn, with a picture of a mammoth etched upon it, was taken from a cave in

France. Flint tools have been found on the Pacific coast in river gravels with the remains of the mammoth and mastodon. They have been found in several of the states in glacial gravels; and have been found associated with bones of extinct animals in a number of places in different parts of the world. Man's work has not only been found in, at present, temperate zones associated with the bones of tropical animals, but also in the same localities associated with the remains of Arctic animals, and bearing evidence of his having lived and died in the localities where they were found.

Sir John Evans, incoming president of the British Association for the Advancement of Science, 1897, said: "We have good evidence that palæolithic man occupied Britain at a time when the configuration of the surface was entirely different from what it is at present; when the river valleys had not been cut down to anything like their existing depth, and when the fauna was of a different character from that of the present day; that the time was sufficient to permit the erosion of valleys miles in width, to a depth of 100 to 150 feet." He rightly refers to the time required as "transcending our powers of imagination" and as being "inconceivable ages."

The time required for the whole geological record of our planet as preserved in the terrestrial crust has been variously estimated, by many up in the hundreds of millions of years and by a few as low as scores of millions. The 7 mile gorge of Niagara, 600 to 1200 feet wide and 200 to 300 feet deep, cut by the river since the Glacial period, taking scores of thousands of years, is yet—only of recent date. The Great Canyon of the Colorado river, 300 miles long, and in places 6,000 feet deep, much of the depth in solid rock, was all cut out

by the erosive action of the river. At the same time the plateau above has been worn down by rain erosion leaving tall "buttes" standing. This work took time.

Rocks ground to sediment, deposited, raised and solidified, and the process many times repeated, and notwithstanding the gaps left by erosion, and the unknown quantities not in sight; that which is exposed to view, the 14 miles of thickness heretofore mentioned, took time and plenty of it. The formation of such deltas as those of the Nile and the Mississippi took time. It took a vast period for the beds composed of the diatoms or of the globigerina to accumulate. Vast periods were required for the lacustrine deposits, and for the coal beds, and peat beds, and beds of lignite, and coral reefs and islands—and the end is not in sight.

There is only one excuse for belittling the antiquity of this record, and that is,—the *bias* that sticks. We have inherited it, and nourished it, and have been baptized and saturated with it, at Sunday school and church. There is no sense in thinking that one generation can free itself from it. There is no merit in believing that which we have plain and reasonable evidence of; but the reward comes from believing the ancient and child-like theory, the miracle, the impossible; that takes *faith*, and that is what we are saved by. We were taught that the world and men were created "very good," and stayed so a few years, and that this was accomplished less than 6,000 years ago, and we are a little afraid to admit even to ourselves the full significance of the newly discovered facts. We cling to the old notions like an Asiatic to a wooden plow. We have changed plows, and have no further use for threshing floors, well-steps, flat worlds, star-lanterns, javelins, bows and arrows, sickles, and the like, but we cannot

shake loose the theological and chronological creations that belong to the same age and are on the same dead level.

Some timid souls have taken it upon themselves to deprecate, what they are pleased to call the attempts of some geologists to over-estimate the duration of the geological periods. We have never seen such attempts, on the contrary there has been universally, from the causes indicated, a tendency to adopt minimum estimates. Under the circumstances it is hardly possible to over-estimate. The present writer confesses to being conscious that he is still influenced by these early "causes," and, as the reader has probably noticed, either refrains from making estimates, or adopts the minimum figures. We do no violence to this superstition when we predict that the time is not far distant when it will be generally admitted among scientists, that men, the forefathers of the present race, although in a transitional state, were already the intellectual lords of the animal kingdom, hundreds of thousands of years ago.

CHAPTER XI.

THE ORIGIN OF SPECIES.

WHEN men first began to wonder how the objects around them, the solid ground, the seas, the trees, the Sun, the Moon and stars, the animals, themselves came to exist, they very naturally ascribed it all to their deified ancestry or mysterious invisible beings possessing the power to make all things. They themselves had made useful implements from wood and flint. Thus were the methods of the gods supposed to be allied to human methods,—Nature's ways being then unknown.

Through all the centuries, and up to very recently, mankind, with few exceptions, have believed that the different species of animals and plants were made from earth,—one week not 6,000 years ago, by special creative power. The species were believed to be fixed. When the science of geology began to gain a foothold, and it became evident that the fossil animals and plants were not the victims of a Noachian deluge, but that they had lived long before the historical or the mythological periods, a new explanation was looked for, one that would not antagonize the old creeds. So it was assumed that the creative power of the deity, had been exerted from time to time during the geological periods as occasion seemed to require. Men had inherited this creation disease, through such a long line of revered ancestry, that no remedy could do more than palliate.

Before the commencement of the present century the great mind of Goethe began to reject the special creation theory and grasp the true solution of the problem. He held that all parts of a flower are modified leaves; that skulls are modified vertebræ, and that plants and animals have been evolved from a few parent types. The new theory was dawning among advanced thinkers and workers like Erasmus Darwin, the grandfather of Charles Darwin, Kant, Buffon, Lamarck, Saint Hilaire and Oken.

In November, 1859, "*The Origin of Species by Means of Natural Selection, or the Preservation of Favored Races in the Struggle for Life*," by Charles Darwin, was published. The great work was supported by the accumulated and tabulated facts. It was attacked by an army of big and little theologians. They knew the weakness of their defences, and attempted to frighten and mislead with clamor.

Defenders like Wallace, Haeckel, Spencer, Huxley, Tyndall, Hooker, Lyell, Draper, Gray and Youmans came to the support of the unpaid truth. Such an avalanche of books, pamphlets, papers and tracts, all upon one subject, the world had never seen. Darwin stood unmoved upon the corner where the advancing thought of the world halted momentarily, and then,—filed to the *right*. The march has been steady and continuous in that direction ever since.

Defeated in their frantic attempt to destroy the Darwinian bridge, the hosts still suffering from the inroads of the creation microbe, are trying to prevent the completion of the approaches, and thus compel their followers to continue to flounder in the quagmire of superstition or to take to the woods. It is a forlorn hope, for the time is near, when the bridges, the highway, the temples and the truths of nature, with all their wealth of utility

and relief, will be free to all. Then men will cease to fear.

We have seen that the primitive notions of mankind regarding the stars, the Earth, the fossils, etc., were wrong, therefore their notions that living beings were miraculously created instead of being naturally produced, cannot be considered as authoritative. The operations of Nature show a continual succession of cause and effect, and for lack of observation, the operation of these natural causes and effects was not understood by the ancients. To those not conversant with the gradual changes of level of the Earth's crust during the later geological periods, with the formation of the mountains, seas, rivers, continents and islands, the miraculous explanation was the only one. The question of the origin of species, being more complex, was of course beyond their ken.

If the numerous varieties of dogs had been found wild, differing as greatly as they now do, would they have been classified by naturalists as belonging to one species? The same question is applicable to horses, cattle, sheep, swine, fowls, pigeons, and every animal that has been modified under domestication. There are great differences in size, color, hair, shape, habits and physical and mental capacity. The resemblance is only general, between the greyhound and the pug, the mastiff and the terrier, the race-horse and the cart-horse or the pony. Their dispositions have become just as decidedly dissimilar. In the care of stock, the shepherd dog has through years of selection, training and breeding for a special purpose, become in some respects almost as sagacious as his master. The race-horse and the greyhound have become slim, long in nose, neck and limbs, with hardened muscle, and all parts adapted through long continued slight changes to the purpose for which they are bred. The individual

variations which are noticeable in all species of animals and plants, have in the cases of domesticated animals and plants been seized upon and perpetuated by breeding and grafting, according to the interest or fancy of their owners. The reader will recall many such instances. I recollect of being delighted when a boy, at a flock of chickens that had been purchased from various sources, and embraced Brahmas, Bantams, Crested Polands, Dorkings, with five toes, Dominiques, and a breed without tails, and another with the feathers pointing toward their heads. Then there were pigs that shed their tails when a few weeks old.

If in variation under domestication, a process of selection where undesirable qualities are eliminated and desirable ones indefinitely retained, results in distinct varieties; then why not form species by the continuance of the same processes through an indefinite length of time. Geology, Archæology and History give all the time required, if natural selection is at all as efficient as human artificial selection.

Great as are the present differences among domestic pigeons they have all descended from a common stock, the rock-pigeon. The dogs could be traced back to a few allied wild progenitors, if the records were complete. The same holds true of the other improved breeds of animals and the improved varieties of fruits, ornamental trees, shrubs and flowers. The same original stock contained the potency, of producing either the Crab-apple or the Tallman sweet, under different conditions. The multiplication of wonderful varieties of roses and other ornamental flowers is looked upon as a matter of course. In garden vegetables remarkable improvements have been made by selection as well as in wheat and other cereals. For example take the Bras-

sica oleracea: there have been produced from it by selection the common cabbage with the leaves modified into a solid edible head; Brussels sprouts, the tender sprouts growing thickly around the stem; kale, with the tender leaves developed separately; kohl-rabi, or turnip-rooted cabbage, and the cauliflower, with the flowers forming a solid edible head. Then there are numerous sub-varieties of all these. We cán form an idea from all this how the existing species of animals and plants have branched off from fewer ancestral forms; they in their turn having been derived from still fewer and simpler forms.

The great improvement of our domestic animals and plants is not due so much to special selections of very noticeable variations, as it is to the saving through heredity of slight, scarcely distinguishable variations by the general practice of selecting the best specimens to breed from, or the best wheat, corn, etc., for seed.

Most people who have had opportunities to live in the country, must have noticed individual variations among animals and plants in a state of nature. Boys who have gathered chestnuts or beechnuts know, that in the same grove hardly two trees will be exactly alike in growth or quality, and that the same is true of the fruit. One tree will yield small light-colored chestnuts, another large dark-colored ones. The burs on one particular tree almost always contain three perfect nuts each; on another, two perfect with a middle one false, and a third tree bears burs that contain one large nut, the side ones being false. Then, there are varieties of chestnuts in a state of nature, quite as distinct as are the varieties of cultivated plums. This feature is common among plants.

All living organisms are capable of adapting them-

selves, to a greater or less extent, to their conditions; and in their turn are modified by their surroundings. The organism acts upon its environments, and they upon it. The tendency of individual animals in a state of nature to vary and form varieties, is as marked, as is the same tendency in plants, and varieties sometimes occur so near the artificial dividing line between nearly allied species as to be hard to classify.

We have then the tendency to variation and adaptation in the state of nature; do we also have selection? Is there a natural selection, capable of preserving the best, as is the case under domestication, where the selection is largely made by man?

Two plants cannot grow in the same place, or prosper if too close together; if attempted, the stronger feeder, the one best adapted all around to the conditions, will survive and the other will dwindle. The one that succeeds will grow vigorous seeds, and give its progeny a better start in life. This principle applies to all animals as well as plants. If there were no competing animals, and rabbits for example were left to freely multiply and obtain food without restriction, in a short time they would cover the Earth. This is true in a large degree of all living things. But every plant has to struggle for its chance at the air, and its roots cross the roots of numerous others in the ground. Every animal finds its pasture encroached upon by many others. There are vastly more animals and plants produced than can by any possibility obtain food and survive to adult age. There is a continual struggle for existence. Those only survive that are best adapted to their conditions. Under this state of things it is evident that any variations, however slight, that are advantageous to the individual in the struggle, will be more likely to

secure the welfare of that individual and enable it to transmit the newly acquired quality to its descendants. The necessities arising from the severity of the struggle have caused the favorable variation to be selected and perpetuated. On the other hand unfavorable variations would in time be eliminated. Nature makes the selection directly—as surely as she does through the agency of man. So we have selection under domestication, and natural selection in a state of nature.

Take for illustration a period of more than usual climatic changes, say the Glacial period; those organisms that had reached too high a degree of differentiation in any one direction, and being, therefore, less capable of adapting themselves to the new conditions, would die out, while the more plastic and less specialized forms would survive. The distribution would be affected also, for Arctic animals and plants, already accustomed to the cold, would extend their pasturage to the south. Variations in the direction of heavier coats of fur, skill in burrowing, fishing, etc., would be retained; less improved forms would become extinct.

No very extreme variations are required to account for the differences that exist between species, on the principle of natural selection; in fact, a variation might be too great to prove an advantage, and be eliminated as a monstrosity. Only the small, useful modifications, corresponding with climatic and other changes, are perpetuated.

It may not be out of place to call attention to a few, out of the multitude of cases, where natural selection has been the means of producing important modifications. There are habits and peculiarities, that serve to conceal the possessor from its enemies or its prey. Such is the case with insects that are the color of the leaves,

bark, or flowers on which they feed. Their color protects them from being so readily seen by insectivorous birds. Those varieties possessing this mimicry in the highest degree were the favorites in the struggle for existence. The tree-frog finds his color useful in decoying his prey. The whippowil lays her two eggs among the leaves on the ground without any nest; the downy young birds are the color of the dead leaves, and it is difficult to tell the old bird from a knot or piece of dead wood. The down on some fruits is a protection against curculio, the beetle attacking smooth fruits in preference. This is like the protecting thorns and prickers of many species of plants. They are either modified limbs or vegetable hairs.

Leaves are metamorphosed in many useful ways. A potato is a leaf changed by being under the surface of the ground. Flowers are modified leaves.

Many kinds of flowers depend upon bees and some other insects, in no small degree, for the distribution of pollen grains to fertilize the female flowers. Natural selection has enabled them to attract bees by the nectar secreted and condensed near the base of the petals, and by their striking beauty. The pollen readily adheres to the hairy covering of the bees and is carried from flower to flower. The tongues or mouth parts of bees and butterflies are also modified by natural selection, to give them sufficient length to reach the nectar of their favorite flowers. So it comes to pass that changes in one or a few species may affect many others.

The Sarracenia, or Pitcher-plant of our bogs, attracts insects to its hollow tubular leaves, that are generally part full of water, in which the insects drown, decay, and help nourish the plant. Natural selection has modified the form of the leaves, the size of the openings,

and the coarse hairs in the throat of the leaves, pointing them downward so the greedy prisoners are less likely to make their escape. To verify this statement look in a convenient marsh for the Pitcher-plant and while there do not forget to search carefully among the thick plants in the bogs for the low-growing, delicate, little Drosera rotundifolia, or sundew. The small, round leaves, fringed with gland-pointed bristles, exude a sticky substance. When a mosquito or small fly alights, or you place a tiny bit of meat on the leaf, the tentacle-like bristles close in upon it and the glands proceed to digest it, and it is assimilated as food. Fed in this way the little plant has not much need for roots, therefore natural selection has been parsimonious in that direction. Transplant some of the best specimens for more careful study. The Dionæa, or Venus's Fly-trap, belongs to the same family of plants. The botanist will never deny the usefulness and truth of the theory of natural selection ; the old notion of special creation is entirely inadequate. To account for all the changing forms, special creations would be required every day in the year.

The sting of the bee is a modified ovipositor, become useful as a weapon. The mouth-parts of the female mosquito, the horse-fly, etc., as modified, are instruments admirably adapted to making a puncture, and enlarging it sufficiently to let the thinned blood pass freely. In the water beetles the posterior pair of legs show in different species a graded adaptability to use as propelling paddles.

The variations necessary for speed that we have noticed in race horse and grey-hound under domestication, have been produced in a state of nature by natural selection, among timid animals whose safety lies in

flight, like the deer and the antelope, and the wild horse. In the domestic animals selection by human agency becomes the finishing touch of natural selection. This is especially apparent in the case of the horse.

A potent factor in natural selection has been the choice of mates by animals when pairing; the successful competitor having to show superiority in strength, beauty, sagacity, color, courage, etc.; the qualities for which he or she was selected standing a better chance of being transmitted to posterity. Thus the sexual selection exercised by the females in many species of birds has led to wonderful beauty of plumage among the males. The peacock may be cited as an example. The superior size and strength of the males quite generally prevailing among the mammals is no doubt due to the same cause,—with fighting qualities instead of beauty the criterion.

Darwin, in discussing the divergence in character, and showing that "The greatest amount of life can be supported by great diversification of structure," says: "But as a general rule, the more diversified in structure the descendants of any one species can be rendered, the more places they will be enabled to seize on, and the more their modified progeny will be increased." This proposition carries with it less competition with similar forms, and seems to be self evident. Then, as a successful variety goes on diverging from its parent stock, its position becomes easier and better assured. Then, all that is necessary for it to eventually become a distinct species is the certainty of sufficient time. As we have demonstrated clearly enough, no one need have any fears of natural operations being stinted for time.

The process, then, can continue on indefinitely, individual variations forming varieties, favored varieties